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Length-weight relationships for aquatic beetles (Coleoptera) in a marsh in Iran

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Abstract: The aim of the investigation was to determine length-weight relationships (LWR) as an alternative method for determining insect biomass. The LWR were calculated for seven aquatic beetles species caught at Choghakhor Marsh in Iran. Individuals' samples were dried at 60℃ for 24 h, cooled in a desecrator, and weighted to the nearest 0.001 g. Each beetle was also measured for body length to the nearest 0.1 mm. The parameters of LWR (a and b values) were estimated by linear regression on the transformed equation: Log $W = \log a + b \log L$. The results indicated that the parameter b on LWR varied between 2.315 and 3.117. Significant LWR with high correlation coefficient (r^2) were found for all species examined. The obtained relations can be used in the determination of the weight of the beetle and they are also useful in addressing many ecological questions. The application of the LWR presented here should be restricted to the observed length ranges.

Key words: Insects; Coleoptera; biomass; body length; body weight; marsh; Iran

1 INTRODUCTION

The relationship between length and body mass is a useful tool in ecological research (Petrakis and Stergiou, 1995; Koutrakis and Tsikliras, 2003; Torcu-Koc *et al.*, 2006). In addition, length-weight relationships (LWR) are used to determine weight and biomass of organisms and also to compare specific growth between different regions (Koutrakis and Tsikliras, 2003). Estimates of LWR are important for converting length observations into weight estimate, *e.g.* weight biomass (Froese, 1998). In fact, LWR is the most widely used approach for estimating biomass as it is easy and more precise than other methods (Benke *et al.*, 1999).

An important parameter in studies of the animal assemblages is dry mass which can be estimated from the population density and individual body mass of component organisms (Kawabata and Urabe, 1998). In addition, chemical preservatives are commonly used to fix invertebrate samples, and may alter their body mass (Johnston and Cunjak, 1999).

Aquatic beetles (Coleoptera) constitute an important part of the organisms of freshwater habitats. Many of them, especially hydrophilids and dytiscids are generally found in small shallow water bodies or on the margin of rivers and marshes. There is a little information on the aquatic fauna beetles of Iran except for some reports from Fars, Gilan, Mazandaran and Khuzetan Provinces by Hosseinie (1992a, 1992b, 1994, 1995a, 1995b), Ardabil Province by Ostovan and Niakan (2004), Markazi Province by Vafaei *et al.* (2007). In this study, the parameters of the length-weight relationship (a, b) are presented for some aquatic beetle species of the families Hydrophilidae and Dystiscidae collected from Chooghakhor Marsh, Chaharmahal-va-Bakhtyari Province, Iran. The marsh is one of the important water ecosystems located among Zagros Mountains. The study area is situated about 30 km south of Shahrekord, the center of the Province. The parameters (a, b) have a biological purpose to enable a weight estimate from given a value of length or vice versa (González-Acosta *et al.*, 2004). The object of the present note is to develop a regression equation for predicting the weight of an insect using its body length.

2 MATERIALS AND METHODS

Samples were taken at the Choghakhor Marsh, close to Shahrekord, the center of Chaharmahal-va-Bakhtyari Province, Iran. The specimens were collected with a metal sieve or net. In the laboratory, each beetle was measured for body length to the nearest 0.1 mm using a vernier caliper and all beetles were kept in a freezer until later measurement of dry weight (for more precision, measurements on

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small insects were done under stereomicroscope). Then, following Miyasaka *et al.* (2007), individuals' samples were dried at 60℃ for 24 h, cooled in a desecrator, and weighted to the nearest 0.001 g using an analytic balance. The parameters of LWR (a and b values) were estimated by linear regression on the transformed equation: Log $W = \log a + b \log L$ (Koutrakis and Tsikliras, 2003), where W is dry weight and L is body length. The constant a is a coefficient related to body form, and b is the rate of growth (*i. e.* slope) of dry weight against length. The significance of the regression was assessed by ANOVA. The statistical analysis was considered significant at $P < 0.05$. This equation is sometimes known as the length-weight key (Biswas, 1993).

3 RESULTS AND DISCUSSION

The regression presented here provides a tool for estimation of some aquatic beetles' weight. The LWR of the aquatic beetle species identified in the current study have not previously recorded for the Iranian Coleopterans. The length-weight relationships (LWR) of 7 species (*Laccobius hindukuschi*, *Hydrochara dichroma*, *Laccobius syriacus*, *Laccobius elmii*, *Enochrus bicolor*, *Laccophilus hyalinus* and *Laccophilus minutus*) representing 2 families are given in Table 1, showing the species, taxonomic authority, sample size, size range (mm), length-weight parameters a and b and the correlation coefficient (r^2). The r^2 values ranged from 0.782 (*Laccophilus hyalinus*) to 0.992 (*Laccophilus minutus*). A significant relationship ($P < 0.05$) was found between length and weight for all specimens examined. The results show that length was correlated with the dry mass of the studied aquatic insects (Coleoptera). Similarly, Sage (1982) and Ganihar (1997) investigated LWR for Coleoptera and established a regression model to estimate population biomass.

Table 1 Results of length-weight regressions

Family	Species	n	Length range (mm)	Weight range (g)	a	b	r^2
Hydrophilidae	*Laccobius hindukuschi* Chiesa, 1966						
	Female	176	2.2 - 3.8	0.0011 - 0.0049	0.0186	2.772	0.971
	Male	134	2.0 - 3.7	0.0008 - 0.0042	0.0151	2.650	0.852
	Hydrochara dichroma (Fairmaire, 1892)						
	Female	117	19 - 38	0.0147 - 0.0328	0.0137	3.075	0.978
	Male	120	17 - 35	0.0123 - 0.0287	0.0101	2.952	0.949
	Laccobius syriacus Guillebeau, 1896						
	Female	97	1.9 - 3.7	0.0004 - 0.0013	0.0079	2.998	0.991
	Male	104	1.8 - 3.6	0.0002 - 0.0013	0.0060	2.883	0.953
	Laccobius elmii Gentili, 2004						
	Female	222	2.8 - 4.0	0.0023 - 0.0067	0.0083	2.878	0.989
	Male	197	2.7 - 3.8	0.0022 - 0.0059	0.0073	2.685	0.918
	Enochrus bicolor (Fabricius, 1792)						
	Female	150	3.3 - 5.9	0.0037 - 0.0084	0.0150	3.012	0.893
	Male	69	3.2 - 5.8	0.0033 - 0.0076	0.0140	2.920	0.981
Dytiscidae	*Laccophilus hyalinus* (De Geer, 1774)						
	Female	234	2.9 - 3.6	0.0029 - 0.0048	0.0603	2.434	0.782
	Male	178	2.8 - 3.5	0.0022 - 0.0046	0.0561	2.315	0.802
	Laccophilus minutus (Linnaeus, 1758)						
	Female	111	2.9 - 5.8	0.0029 - 0.0066	0.0118	3.117	0.914
	Male	145	2.8 - 5.6	0.0028 - 0.0059	0.0105	3.001	0.992

Length-weight relationships (LWR) were calculated using the least squares regression on log transformation of the equation $W = aL^b$, where W = weight, L = length, a = constant, and b = slope, the rate of growth.

The relationships were described in relation to sex (female and male) and family. In relation to *b* values, females of both families, *i. e.* Hydrophildae and Dytiscidae had steeper slopes (*i. e.* larger *b* values) than males which were attributed to the allometric enlargement of females with sexual maturation (Miyasaka *et al.*, 2007). This indicates that the rate of increase (*i. e.* slope) of dry weight against length in females was higher than that in males.

LWR is a critical step in addressing many ecological questions at organism, population, community and ecosystems level of organization (Benke *et al.*, 1999). In fact, the fastest way to estimate the biomass of aquatic beetles is to use the LWR (Gonzalez *et al.*, 2002). LWR has been suggested as an alternative method for determining insect biomass (Bradley *et al.*, 1993). Therefore, the obtained relations of the current study provide useful tools in estimating aquatic beetles' biomass in this area. Likewise, Rogers *et al.* (1976, 1977) used the relationship between length and weight of insects and many other invertebrates and developed a generalized regression model for determining the dry weights of insects from their lengths.

It should be noted that the application of these relationships should be limited to the observed length ranges; otherwise it may be erroneous (Petrakis and Stergiou, 1995; Froese, 1998). Season, habitat, gonad maturity, diet and stomach fullness, health, and preservation methods (Tesch, 1971) may influence the LWR which were not considered in the present study. For example, LWR in aquatic beetles appears to be influenced by many factors like body shape, size range, feeding habits (herbivorous or predatory), behaviour (flying or non flying), life stages (larva or adult) and the metabolic rate (Sage, 1982; Ganihar, 1997). Thus the coefficient of length-weight regression can vary significantly between taxa (Rogers *et al.*, 1977), and within taxa between regions (Schoener, 1980).

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伊朗一沼泽中水生甲虫体长与体重的关系

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摘要：本研究所用标本为 7 种水生甲虫，均采自伊朗 Choghakhor 沼泽。通过对水生甲虫的体长和体重的测量，研究其体长-体重关系（LWR）。结果表明：LWR 参数 b 的变动范围在 2.315 ~ 3.117 之间。所有被观察的水生甲虫体长与体重关系明显，相关系数（r^2）均高。本研究所得到的这种相互关系可被用于确定甲虫体重，并有助于解决其他的一些生态学问题。本研究所提出的体长-体重关系（LWR）限制于所观察到的标本体长范围。

关键词：昆虫；鞘翅目；生物量；体长；体重；沼泽；伊朗

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